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Review

How to apply Simulation-Based Learning in Medical Education?

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ABSTRACT

Simulation-Based Learning is considered the best alternative teaching and assessment tool that able to make the change in education, training, improving the quality and assessing the performance of the medical students. It helps students for acquiring many skills such as professionalism, communication, self-evaluation, time management, and teamwork. In addition, the use of simulation in medical education is based on many noble goals and ethical rules; it provides the best standards for patient care and safety, patient autonomy, and social justice. However, assessment of the application of simulation appropriateness depends on validity, reliability, and utility. Simulation has many types and classifications; it may be classified into human simulation such as role-play and standardized patient or non-human simulation such as manikin and the based computer simulation. It may be also classified according to the type or the fidelity. According to the type, it is classified into compiler-driven and event-driven, or according to the fidelity as a low, medium, and high-fidelity. There are specific criteria and steps that should be applied when designing a simulation course or operation a simulation training session as well as designing a skill checklist for ensuring a successful simulation application in medical education. However, many challenges and obstacles are still facing simulation implementation in medical education in different medical schools.

1. INTRODUCTION

The use of innovative teaching methods became a necessity for the development of medical education in the last years because of the bad performance of most of the medical graduates especially in the clinical skills performance and application of knowledge and problem-solving in critical situations [1].

Simulation-Based Learning is considered an essential part of practical learning. It is an active learning process; it should be involved besides the other teaching methods in medical schools to overcome the problems of using the real patient in the teaching such as his ethical and legal rights, and the lack of critical events that are a source of learning and acquiring of different skills. It is the best alternative teaching and assessment tool that able to make the change

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in education, training, improving the quality and assessing the performance of the medical students [2].
In the last years, the simulation-based medical laboratory education becomes a common trend in modern medical education in different medical schools in the world as a method for development and innovation in the medical curriculum. Simulation-Based Learning provides controlled, virtual, simulated, and clinical laboratory environment that allows integration of the theory with hands-on skills for practice and mastering the skills, and assessing the applied skills [3].
Simulation-Based Learning is characterized by pedagogical strategies, technology, task complexity, task breadth that prepare the students for work in a clinical laboratory with workload and workflow. Therefore, the construction of the medical simulation lab on the sound foundations has many different scientific and logistic aspects that should be considered such as administration, design, technology, instruction, facilitation, and evaluation. Noteworthy, it has many different names in the different medical schools such as skill lab, the simulated lab, simulated clinical practicum, clinical skills center and the medical simulation center [4].

2. SCOPE OF SIMULATION-BASED LEARNING

Application of simulation in medical education has different positive impact aspects; it can provide a relaxed, safe and pedagogical environment that is conducive to acquire good learning experiences and provides also a suitable atmosphere psychologically to make mistakes and its correction leads to reinforce the quality of the learning environment. Simulation is considered an ideal situation for bridging the gap between theory and practice whereas there is an integration between basic and clinical sciences because the trainee should learn the related basic sciences to the skill before the starting point of the training session. It gives also an appropriate trainer/trainee ratio wherein the trainer allocates more individual attention to the trainees and more time for answering their questions [5].
In addition, Simulation can prepare the trainees (medical students) well for doing their responsibilities during their work field in the future with more self-confidence and morale to face the challenges and unusual situations. It gives also the chance for the trainees to assess their own abilities and to measure their own progress through giving an opportunity to the trainee for practice, repetition and remediation wherein the trainee gets more time for the phase of hands-on via using available simulators for the teaching purposes [6].
Furthermore, simulation addresses the shortage of health human resources and the limited number of clinical sites leading to relieve the burden of clinical education. It fosters also the independent work of the trainee (medical student) and helps him for acquiring many skills such as professionalism, communication, self-evaluation, time management, and teamwork. Therefore, simulation increases the degree of trainee acceptance by the health workers in the clinical field leading to good psychological support for him [7].
The use of simulation in medical education is based on many the noble goals and ethical rules, it provides the best standards for patient care and safety, patient autonomy, and social justice, besides the qualified training, and error management. Therefore, the trainee encounters the real patient when he has a high technical and clinical proficiency, and then the probable harmful effect on the patient may be prevented absolutely or it is decreased to the lowest level at the least. It provides also the best standard for medical education and evaluation wherein the responsibility of trainers is to provide well-trained physicians because of the use of the overall evaluation method that assesses psychomotor, attitude with the cognitive domain [8].
In another context, although the simulation is considered a viable and interesting learning method, not every learning objective may achieve by using the simulation. Thus, the effectiveness of the simulation use depends on accurate determination of the appropriateness of specific simulation for a particular purpose if we want to optimize the benefits of the simulation use in medical education [9].
Therefore, assessment of the appropriateness of the simulation application for a specific purpose should depend on validity, reliability, and utility. The validity of simulation use means homogeneity with the real clinical field. The use of simulation should have expectable outcomes for discovery and mastery the learning. We should also determine if specific objectives achievement may be better, more efficient and less expensive by using another method or not to assess the utility of the simulation use [10].
Finally, the effectiveness of simulation means that not all simulation types have the same efficacy wherein not every type of simulation is considered valid equally for all the types of teaching. Simulation types should be assessed depending on their design and the expectations for its ability to achieve because there is not any type of simulation that can do all tasks effectively. Thus, we should select a suitable type of simulation for every learning objective to ensure its good achieving [11].

3. SIMULATORS

There are many types and classifications of simulation; it may be classified into human simulation such as role-play and standardized patient or non-human simulation such as manikin and the based computer simulation [12]. In addition, there is another classification wherein simulators may be also classified according to the type or the fidelity. According to the type, it is classified into compiler-driven and event-driven. The compiler driven is a specific task trainer representing a part of anatomy with different levels of sophistication for training on specific procedures such as the arm for intravenous line insertion, leg for suturing or male genitalia manikin for urinary catheter insertion while

the event-driven type consists of the standardized patient (simulated patient), hybrid simulation and computer-based simulators [13].

The fidelity means full interactive simulation and a suitable clinical work environment. Therefore, it gives the chance to the trainer to use the equipment and perform a task in a real environment with psychological adaptation for the situation. Learning experiences that are acquired by the use of high-fidelity simulators are completely different depending on the level of training environment because the high-fidelity environment is more important than high-fidelity simulator for acquired learning experiences [14].

According to the fidelity classification, the simulators are divided into three categories; low, medium, and high-fidelity. The simulator that focuses on a single skill and allows the trainers to practice in isolation is called a low-fidelity simulator while the medium-fidelity simulator provides a more realistic simulation but it does not allow the trainer to be fully immersed in the situation. A high-fidelity simulator permits the trainer to be fully immersed concomitant with having a response to the treatment interventions [15].

In more detail, low-fidelity simulators consist of screen-based text simulators that create scenarios with different responses that are differentiated and selected by the user and the static manikins that are used for hands-on practice such as intubation and cardiopulmonary resuscitation manikins. Medium-fidelity simulators consist of screen-based graphical simulators and the mechanical manikins; screen-based graphical simulators demonstrate the pharmacokinetic and dynamic of the drug administration but it prevents the trainee from being fully immersed in the situation while the mechanical manikins contain software (interactive simulators) such as some cardiopulmonary resuscitation manikins [16]. The high-fidelity simulator is a full-body manikin that likes the real patient; this simulator can speak with the trainee, blink with a pupil reaction to the light, breathe and produce the urine with demonstrable peripheral pulses and blood pressure, and measurable gases. Administration of the drugs into this simulator produces a suitable physiological response according to the programmed age and sex while the level of consciousness and cardiac rhythm are also demonstrated in this type of simulators [17].

Finally, high validity of simulator means its high fidelity; it has the high degree of realism because it provides an approximation to the complex clinical situations that are necessary for the trainees to reinforce their response to the critical circumstances while the face validity of simulation is related to the generalizability of the simulation setting to the real patient setting. In addition, creation a realistic environment such as an intensive care unit using an audio-visual system completes the role of the high-fidelity simulator and increases the level of training and immersion leading to an improvement in the skills performance. The virtual reality trainer is the simulated patient in three dimensions world wherein (3D) environment may be seen on a graphics monitor like a virtual workbench or total immersion virtual reality which allows the chance for interaction and navigation in three-dimensional space [18].

4. STANDARDIZED PATIENT (SP)

The standardized patient (simulated patient) is a type of human simulation that uses a well-trained healthy person (actor) to play the role of the real patient with stimulating his physical condition wherein the trainees (students) can train on the skills of history taking, communication, patient counseling, health education and physical examination in a safe simulated clinical situation. The simulated patient (standardized patient) is a dynamic learning method that is used in an interactive teaching sitting to improve the professional conduct of the trainee (student) as in the real situation, it also is used in the clinical examinations such as an objective structured clinical examination (OSCE) to test the acquired clinical and communication skills of the trainees (students). Furthermore, the standardized patient may also be used in combination with a specific part-task trainer in simulation sessions for more the simulated scenario realism with an additional challenge for the trainees such as achieving a technical skill. Therefore, this type of simulation is called a hybrid simulation [19].

Moreover, the job of the standardized patient is considered hard work because it requires a high level of performance, and then it is not a job for everyone. Therefore, the standardized patient should be characterized by the healthy mind and body, intelligence, reliability, promptitude, good memory, ability to listen and understand well, competence of concentration and rapid response during the training and the encounters, flexibility, punctuality, excellence of verbal and written communication skills, stability in the emotions, honorable spirit and good articulation [20].

Candidates for the job of the standardized patient may be from different ages and professional backgrounds but they should have a credible desire for helping the trainees to learn. The simulated patient should recognize that he is a reproducible patient who can give a medical history of the patient and simulate his physical findings associated with the same body language and emotions of the real patient in the real situation. Furthermore, the simulated patient may be a usual person, actor, nurse or health worker but he should receive good training on specific health problems (complaints) such as abdominal pain or emotional situations such as the death of the child. The volunteer may also be used as a standardized patient whether he has normal or abnormal physical condition [21].

Finally, we should not overlook the following important fact during the talk about the use of the simulated patient in medical education. If we need specific personal characters for these who play the role of the standardized patient, we need also well-trained facilitators or trainers to design accurate and reliable clinical scenarios simulating the real situation and to train these persons well on the application of the role of the standardized patient with frequent quality

assessment for their work to ensure their ability to play role the patient successfully.
In addition, I want remind that the use of the standardized patients in the clinical training is not a substitute for the training in the real clinical situation (hospital) via using the real patients because the training in the real clinical situation gives the opportunity to the trainees (students) to explore abnormal and pathological cases.

5. VIRTUAL STANDARDIZED PATIENT

Some medical educators still have many concerns for the application of standardized patient in medical education because of availability, cost, time-consuming and the training of actors. From this point of view, the development of the virtual standardized patient became a necessity as an alternative to the true standardized patient (actor) for training and assessment of students. Virtual standardized patient provides a virtual learning environment that helps the trainees to acquire and practice the clinical skills leading to more cost-effective and validation of the skill performance. Moreover, the virtual standardized patient is realistic, responsive, intelligent and emotional wherein the trainee can talk with him naturally [22].
The design of the virtual standardized patient is the integration of different technologies that can provide a programmed system for emotions and behaviors, natural language processing, facial expression and lip reactions to simulate an interview between the patient and physician. In addition, some advanced simulators can perform this task by providing a patient history, real interactive physiological response, 3D simulated scenarios and the records for the realistic physical examination [23].
The virtual standardized patient can recognize natural or unscripted talk; understand the words and sentences consistent with the content of discourse with the expectation of the relevant verbal response of the trainee as the usual conversation [24]. Furthermore, the virtual standardized patient can also express his pain, anger, and depression by facial expression according to the context of the virtual surrounding environment. In addition, the physical examination may be achieved on the virtual standardized patient by using an interactive 3D program that shows suitable signs and symptoms according to the designed scenario with a suitable realistic physiological response to an emergency or abnormal incident such as bleeding, trauma, and hypoxia. This program can also interact with successful or failed medical interventions such as giving a drug [25].
There many distinctive benefits for the virtual standardized patient in comparison with the true standardized patient (actor); the virtual standardized patient is considered a computerized virtual patient who interacts with the trainee as the true standardized patient (actor) in the presence of a facilitator wherein the training and assessment are easier to control. The virtual standardized patient is characterized by availability and adaptability whereas an automated modification may be performed to alter the personality, history and physical condition of the patient with a simple replacement for the designed scenario. Therefore, It is considered a useful versatile and reproducible training tool by using different virtual numerous scenarios [26].

6. ROLE-PLAY SIMULATION

Role-play is an effective simulation technique that studies the behavior of personal interactions through the creation of real situations models by learning through acting. It is considered a type of experiential learning that shows how the emotional aspect affects cognition and behavior; it is a task performance in a simulating realistic situation as the real situation whereas it gives the chance to the trainees for absorbing the knowledge and acquiring new specific skills that reflect on their behavior [27].
The use of role-play simulation in medical education is very important for learning and acquiring communication skills wherein the trainee develops an interpersonal interaction (conducting interview) in specific circumstances. It can help the trainee to manage many aspects of difficult communications in the critical situations that generate unprofessional behavior towards the patient such as breaking bad news. Moreover, it is also an effective method for gaining the experience wherein the trainee can restore his previous experiences (personal feelings) in a specific situation and analyzes how physician or patient behaves in this situation with assessment and predicting their reactions. It may be used for training on interview skills through history taking, physical examination, health education for the patient and dealing with a difficult patient or with a critical situation. We can also mention that the role-play simulation may use in the objective structured clinical examination (OSCE) as a station for the students' assessment [28].
In this context, some instructions should be applied to getting an effective role-play session. Firstly, it should determine clear objectives about the task and the roles that reflect the real experiences and challenges that are related to the broad learning context. It should also expect the difficulties in the role-play application to overcome it by providing enough time for the preparation stage. It should respond to the desire of trainees for working with their friends to create a motivating atmosphere for a successful role-play session. The use of debriefing, summarization of experiences and the use of audiovisual recording for the session are considered important tools for an effective role-play session besides the presence of an enthusiastic and well-trained facilitator. Recognition of the benefits of social interactions and the role-play through structured feedback from the trainees and trainers are also considered important issues to establish an effective role-play session [29].
I think that the success of the role-play simulation in medical education depends mainly on accepting the

trainees (students) the duties and responsibilities of their roles, and then their ability to do their best in the simulated situation where they find themselves. Thus, the resistant trainees to acting the role-play simulation is considered an obstacle that stands against its application because of their culture and they are unfamiliar to work experientially leading to generate unwillingness to involve in this type of simulation. Therefore, the gradual introduction of the role-play simulation is necessary to overcome this obstacle and help the trainees to engage in these simulation sessions. The second obstacle is the resistance of faculty members who do not recognize the usefulness and importance of the role-play simulation wherein they have not any ability to gain new training experiences that help to train the students by using this type of simulation (role-play).

7. HOW TO DESIGN AND APPLY A SIMULATION COURSE

Many steps should be followed to design and apply a simulation course. At the first, it should define the learning objectives and then discuss the opinions and suggestions of the staff members with construction the structured teaching program and identification the simulators types that are used for applying the intended learning objectives and then how to prepare simulators, infrastructure, maintenance, funding, and the manpower [30].

Staff members training programs should be performed after the allocation of the needed number and the working hours. The blueprint preparation of the teaching program should be carried out to determine the number of clinical training sessions for every skill to master this skill based on a determination of the standard quality of the student performance with specifying textbooks, international guidelines or checklists as scientific references [31].

To improve the quality of the simulation-teaching course, it should carry out a rehearsal for the course by the staff members with obtaining feedback from and to the students after the course implementation. In addition, we should assess the performance of the student and the extent of skills mastering via using a valid and reliable method such as a checklist, besides evaluation of the whole program to get feedback about the strength and weak points for further improvement [32].

8. HOW TO OPERATE A SIMULATION TRAINING SESSION

Initially, the understanding of Miller's Pyramid of Competence may help in drawing the road for the best running of the simulation training session because it determines the role of learner (trainee) and the instructor (trainer). According to Miller's Pyramid of Competence, the trainee should move from stage to the other for reaching the mastery of the skill as the following:

- Knows "Learn knowledge".
- Knows how "To use the learned knowledge".
- Shows "How to use the knowledge".
- Does "Perform in practice".

The trainer should also move through the same stages for helping the trainee to hone the skill as the following:

- Knows "Content to be taught".
- Knows how "To teach".
- Shows "Teaching is delivered".
- Does "Teach effectively" [33].

There are many design forms of training sessions. Some prefer to design a simple training session for a manual single technique that represents a common form of the direct contact of the student with the patient such as venipuncture. The others prefer a complex session that gives the chance for cumulative skill-building, time management, and multi-tasking wherein activities may vary and progress from manual to semi or fully automated procedures, or from single to multiple techniques such as complicated case study by using a high fidelity simulator [34].

A preparatory phase should be carried out before the starting of any training session. At first, the students should be divided into small groups; every group consists of ten students as an optimum and maximum number for a suitable and effective training session. Secondly, a well-trained qualified facilitator (instructor) should be chosen for every group. Thirdly, the selection of skills for the simulation session according to specific criteria. These selected skills should be integrated with the objectives of the curriculum as a whole and with every specific educational module. It should also be complementarily with the clinical field, wherein it is difficult to be performed in the clinical field such as a per-rectal exam or urinary catheterization insertion or vaginal exam; it should also be have a commonality related to the clinical field such as blood pressure measurement. Moreover, the selected skills should have a priority for competency based on the objectives of the program and need time for the student to repeat practice (repetition) [35].

Noteworthy, the preparation of the student for a simulation session is essential for the success of the session. In this context, the student preparation has many different aspects such as mini-lecture to explain the scientific anatomical background of skill, watching a videotape for demonstration the specific technique that should be an ideal standard, a review material on the theory related to the procedure or seminar related to the specific skill technique [36].

The phase of hands-on is an actual training session that gives the chance to the students to perform the skill procedure under the trainer (facilitator) supervision. At first, the facilitator starts to perform the practical steps of skill on the simulator (manikin or standardized patient) according to the skill checklist that should be held by every student in the session. The instructor (facilitator) should explain the steps while his hands carry out the procedure at the same time to prevent transforming the training session

into a lecture. After that, every student should perform the same skill procedure on the simulator under the observation of his colleagues and the facilitator who corrects the mistakes of student immediately. All group students should repeat the same procedure sequentially not in a parallel manner to maintain a high level of hands-on via the learning from the mistakes of their colleagues leading to promote the value of learning, reflective practice, critical thinking, and assessment. Some prefer that all students perform the same training activities at the same time if there is availability for the simulators and other tools of training, but this direction in the training is not encouraged because it does not give the chance for the students to watch the repetition of the practice that carried out by their colleagues. However, if the students work on a case study through using an advanced simulator, they can discuss and share the related knowledge, and then debrief the learning activities at the end of the session [37].

9. HOW TO DESIGN A SKILL PROCEDURE CHECKLIST

The checklist is one of the most essential tools in training sessions; it is the practical steps of the skill performance. Therefore, it is considered the part of the preparatory phase of the student as well as it is also a fundamental part of the hands-on phase. Thus, many guidelines should be applied when the checklist is designed. The checklist should contain some legal and ethical aspects that should be learned and practiced by the student such as the following instructions:

1. The student should introduce himself to the patient.
2. The student should take permission from the patient for doing an examination.
3. The student should call the patient by his name during an examination.
4. The necessity of presence the assistant (nurse) during the examination such as vaginal and breast examination.
5. The student should explain the procedure to the patient such as per-rectal examination.
6. The student should wash his hands before and after examination by using an antiseptic solution.
7. The student should warm his hands before the examination such as abdominal examination.
8. The student should use disposable gloves before the examination (per-rectal and vaginal examination).
9. The student should dress a professional white coat.

Moreover, the checklist should also contain some general considerations that are important scientific points related to the skill procedure such as the position of the patient and examiner as the following:

1. The patient should be lying comfortably in a supine position.
2. The arms of the patient should be at the side or folded across the chest.
3. The knees of the patient should be flexed to relax the abdomen.
4. The student should stand on the right side of the patient.
5. Use the right hand, if you are right-handed.
6. Expose the abdomen from above the xiphoid process to the symphysis pubis.
7. It should examine the healthy organ at the first and then unhealthy and compare in between if there is a pair of organs such as breast, eye, and ear.

In addition, the checklist should contain the practical steps of the skill without any theoretical information. The practical steps of the skill should be written in the checklist by using the verb in the form of command or present tense such as percuss or palpate. It should also be written in simple, clear and short wording whenever possible. The checklist may contain some simple and short comments in between brackets about the results of the specific procedure or practical test such as (a negative Rinne test means conductive deafness). It should contain one technique for any examination if there are different techniques for this examination. One technique for any examination can prevent the dispersion of student attention especially undergraduates. Moreover, the focus on the repetition of certain skill procedure gives better value than the focus on the experience breadth and the variations of the examination methods. For example, the technique of carotid pulse examination may be done by using thumb only or by using three fingers together, so it is better that the checklist contains the carotid pulse examination by using one technique (thumb or three fingers). The checklist may contain some illustrative images for some practical steps. Moreover, it may also be used as a student assessment method when it contains the degrees for measurement the student performance quality such as not done, done but not well, and well done that may be translated into a specific score. Finally, the checklist should be written by a medical specialist or consultant, and then a scientific committee should revise it to ensure that the above rules were applied [38].

10. CHALLENGES AND OBSTACLES

There are many obstacles that face using the simulation in medical education. Firstly, its tools are not as diverse as human and then it does not simulate the real situation (low fidelity) exactly beside its high cost and the need for a suitable infrastructure to conduct a new simulation technology, and then the implementation of the simulation course within the medical curriculum will require high investment. Secondly, the practice in the simulation centers leads to changes in the learner behavior that do not occur in the clinical situation wherein some learners are

hypervigilant and the others are cavalier because there is not real human life [39].

No doubt that there are also many challenges that face the creation of the simulation course in medical education; the first challenge is the resistance of the staff members against the use of simulation as an innovative teaching tool because of the lack of motivation and enthusiasm for renewal. The second challenge is the lack of well-trained instructors who have experience and the art of teaching for using the simulators as well as the lack of technicians who can deal with the simulators and maintaining them. Furthermore, the high cost of simulators represent as a major challenge in the present time and in the future wherein it is increased with developing of the technology, So the capital and operating costs for construction of a medical simulation center are considered for the sustainability of the simulation lab and its development in a parallel way with the advances in the relevant and authentic technology of simulation. Briefly, the availability of all resources such as financial, logistic and administrative aspects as well as human resources, and a well-equipped place of the lab are considered challenges because it is integrated with each other apart from the familiar saying that tells "we can simulate anything if we have enough money. So, the limitation of the resources whether individually or combined can restrict what can be simulated [40].

The scheduled of the simulation course and choosing a suitable time for the course are also considered challenges; some decided that the most suitable time to introduce the simulation course in the curriculum is prior the trainees transition to the clinical field (hospital) because it shows honest expectations to the trainees about the clinical work and prepares them for the responsibilities of the workplace and for taking the charge of their own learning. They build their opinion based on the simulation lab is the field of training while the hospital is considered the field of practice and then the field of training should be prior to the field of practice. Conversely, the others adopt the integration between the simulation lab and the clinical field in the same curriculum and module whereas it should be in a sequence time because the simulation lab is complementary to the clinical field [41].

Finally, the simulation course needs well planning and enough time to introduce and apply in the medical curriculum according to the target learning objectives of the course and the needs of the learners in this course to integrate with the acquired knowledge. So, design a good simulation course needs flexibility, coordination, scientific and administrative support that is also considered a challenge.

11. CONCLUSION

Simulation-Based Learning helps students for acquiring many skills such as professionalism, communication, self-evaluation, time management, and teamwork. Its application gives the best standards for patient care and safety, patient autonomy, and social justice. Simulation may be classified into human or non-human simulation, or according to the type, or the fidelity. Specific criteria and steps should be applied to get a successful simulation implementation in medical education. However, the simulation application in medical education is still facing many challenges and obstacles until now.

12. DECLARATION OF CONFLICTING INTERESTS

The Author declares that there is no conflict of interest.

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